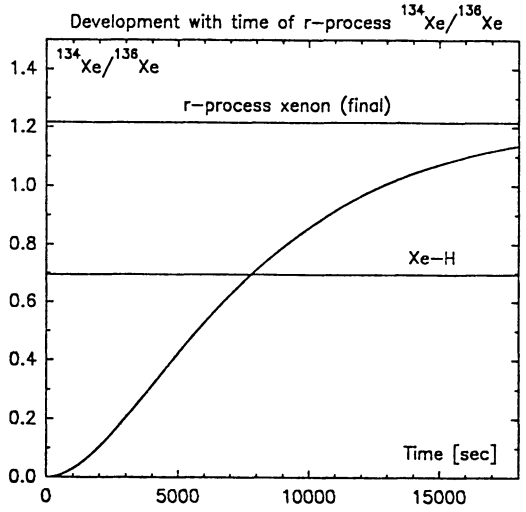

Fig. 1.

Xe-HL) without evidence for such a process to have contributed significantly to anything else, is not a very attractive solution. Here we consider instead that Xe-H is basically "normal" r-process Xe that a chemical fractionation effect has turned into Xe-H. In doing so we compare r-process Xe with "pure" Xe-HL (i.e., Xe-HL extrapolated to $^{130}Xe \equiv 0$, where "real" HL-Xe is the product of mixing with approximately normal Xe).

The r process acts on a rapid (~1 s) timescale [e.g., 3], producing neutron-rich nuclides far from stability, that subsequently decay via a series of β decays into stable end products. As the precursors of the different Xe isotopes have different lifetimes, the isotopic composition of the Xe in supernova ejecta will be time-dependent on that timescale. From Fig. 1, where the development of the $^{134}Xe/^{136}Xe$ ratio is shown, it is obvious that after ~2 hr this ratio is equal to that of "pure" Xe-H. If, at that time, a chemical separation can be achieved between the Te and I precursors on one hand and Xe on the other, we are left with Xe for which this ratio is identical to that in Xe-H.

At this time little $^{129,131,132}Xe$ will have been produced, because their precursors have much longer half-lives. In order to account for the small but nonzero abundances in pure Xe-H of these isotopes, on the order of 5% of fully developed r-process Xe may have to be admixed, an observation supported by the fact that in "pure" Xe-H these isotopes occur in ratios relative to each other that are consistent with r-process Xe proper. Also, because in the p process ^{126}Xe is in part originally produced as ^{126}Ba with a half-life of 97 min, a separation of Ba from Xe on a similar timescale may account for the fact that $(^{126}Xe/^{124}Xe)_L < (^{126}Xe/^{124}Xe)_p$.

Condensation comes to mind as an obvious means to achieve a separation between Xe and the other elements, but timescales usually associated with the formation of supernova condensates are years rather than hours. We note, however, that for certain assumptions about the cooling process of supernovae, the first condensates may form in the ejecta after ~10^3–10^4 s already [4]. Taken at face value, the existence of Xe-HL may serve to support such a fast cooling scenario.

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RHENIUM-OSMIUM IN IRON-NICKEL, SULFIDE, AND PHOSPHIDE: THE POSSIBLE DETERMINATION OF INTERNAL ISOCHRONS FOR IRON METEORITES. D. A. Papanastassiou, J. J. Shen, and G. J. Wasserburg, The Lunatic Asylum, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena CA 91125, USA.

For age determinations of specific events in the evolution of iron meteorites, it is essential to obtain a reasonable range of physical-chemical fractionation of Re-Os. The possible stages of iron meteorite evolution that can, in principle, result in Re-Os fractionation include (1) condensation of PGE and of FeNi in the solar nebula; (2) subsequent oxidation of part of the Fe by reaction with S; (3) segregation and partial removal of massive FeS during melting on parent planetesimals; (4) melting followed by fractional crystallization of the metal phase and crystallization of the remaining FeS; (5) element redistribution during subsolidus phase transformations to produce schreibersite sheaves; and, finally, (6) precipitation or exsolution of minor microphases, e.g., rhabdite, at a later stage. Using negative-ion, thermal ionization, we have determined the Re and Os concentrations and Os isotopic compositions in metal samples of iron meteorites. We have also analyzed metal-FeS pairs from two IA iron and a metal-phosphide pair from one IIIA iron. The analytical results for the paired analyses are shown in Table 1. The Re-Os partition coefficients between these coexisting phases are shown in Table 2. The whole-rock, metal samples for group IA, IIA, IIIA, IVA, and IVB irons are consistent with a single, well-defined best-fit line that yields a slope of 0.07863 ± 0.00031 (corresponding to an age of 4.62 ± 0.02 aeons; $\lambda = 1.64 \times 10^{-11}$ a^{-1}) and an initial $^{187}Os/^{188}Os = 0.09560 \pm 0.00018$ (all uncertainties are 2σ). There is also a suggestion from the data for the IIA and IVA groups of a difference in ages of 60 ± 45 m.y.

We find that, in the presence of the metal phase, neither Re nor Os enter into the sulfide. Therefore, the production or segregation of sulfide [e.g., under steps (2) and (3) above] act only as diluents for the Re and Os concentrations and can have no influence on the Re-Os isotope systematics and age determinations. Given the refractory nature of Re and the PGE, under the reducing conditions in the solar nebula, we consider that the condensation of Re and the PGE and their subsequent incorporation into the FeNi did not result in significant Re-Os fractionation. We conclude that the data for the nonmagmatic IA and IVA groups show a limited Re-Os fractionation and that the major dispersion in Re-Os for FeNi is obtained for members of the magmatic Fe groups and is dominated by the melting and fractional crystallization of the metal phase. This Re-Os fractionation process then enables the determination of essentially whole-rock isochrons for iron meteorites, which date the melting and fractional crystallization of the metal phase on the parent planetesimals. The data on the Tres Castillos (IIIA group) FeNi show relatively low Re and Os concentrations, consistent with the Ni concentration. The results on the Tres Castillos FeNi are consistent with the well-defined, whole-rock Re-Os isochron determined by all irons analyzed. The data on the massive schreibersite lamella (3 cm × 5 mm) show low but significant levels of Re and Os, with metal-to-schreibersite partition coeffi-

TABLE 1. Re-Os analytical results.

Sample	Re (ppb)	Os (ppb)	$^{187}Re/^{188}Os$	$^{187}Os/^{188}Os$
Canyon Diablo (IA)				
FeNi	209.7	1982.	0.5103 ± 7	0.13561 ± 3
FeS	0.51 ± 4	1.26 ± 4	1.9 ± 0.2	0.127 ± 4
Odessa (IA)				
Fe Ni	231.5	2428.	0.4594 ± 3	0.13168 ± 3
FeS	1.07 ± 8	1.77 ± 6	2.9 ± 0.2	0.128 ± 2
Tres Castillos (IIIA)				
FeNi	20.88	164.	0.6135±6	0.14371 ± 4
$(FeNi)_3P$	1.89 ± 2	5.65 ± 1	1.63 ± 0.02	0.2146 ± 13

Uncertainties are 1‰ when not explicitly listed.

TABLE 2. Re-Os partition coefficients.

Sample	$C^{Re}(M/S)$	$C^{Os}(M/S)$	$C^{Re}(M/P)$	$C^{Os}(M/P)$
Canyon Diablo (IA)	380	1500	—	—
Odessa (IA)	224	1300	—	—
Tres Castillos (IIIA)	—	—	11.1	29.0

cients of about 11 and 29 for Re and Os respectively. The data furthermore demonstrate that the schreibersite has Re-Os that is significantly fractionated, by a factor of 2.7, relative to the coexisting FeNi. The schreibersite data yield a model age of 4.30 ± 0.09 aeons, indicating a disturbance at a time younger than 4.30 aeons. The FeNi-schreibersite pair yields a two-point line with a slope corresponding to an age of 4.11 ± 0.11 aeons. We consider this relatively young age as an indication of (1) a relatively late disturbance of the phosphide; (2) an indication of a relatively slow cooling rate at 1°–2°C/m.y.; or (3) an indication that even the massive schreibersite may continue to act as an open system at reasonably low temperatures. We also consider that the Re-Os data on the schreibersite permit for the first time the application of the Re-Os system to the determination of a possible internal isochron and possibly a direct measurement of cooling history.

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EXSOLVED FERROMAGNESIAN OLIVINE: WHY ONLY IN DIVNOE? M. I. Petaev, Harvard-Smithsonian Center for Astrophysics, Cambridge MA 02138, USA.

Recently Petaev and Brearley [1] showed that lamellar structure in olivine grains in the Divnoe meteorite was produced by the low-temperature exsolution of primary homogeneous grains. Exsolved olivine in Divnoe is in accordance with the thermodynamic model of olivine solid solution of [2], which predicts a miscibility gap in ferromagnesian olivines below ~340°C within a compositional range that widens with decreasing temperature. Experiments on the coexistence of olivines having a range of compositions with aqueous solutions of (Fe,Mg)Cl2 [3] suggest that exsolution in ferromagnesian olivines could occur even at temperatures as high as ~400°–450°C. However, [1] remains the only observation of exsolution in natural olivines so far. This means either that (1) the exsolution in Divnoe olivine is unique or (2) olivine grains in other slowly cooled coarse-grained rocks have not been studied closely enough to detect them. This work attempts to clarify the issue.

Olivine grains from selected meteorites (Springwater pallasite, Lowitz mesosiderite, ALH 84025 brachinite, Gorlovka H3-4 chondrite and Krymka L3 chondrite, and the Calcalong Creek lunar meteorite) and terrestrial rocks (San Carlos forsterite and Rockport fayalite) were studied by EPMA using the same equipment and technique as in [1]. Among meteorites, pallasites and mesosiderites are known to have the slowest cooling rates at low temperatures. Olivines in the Springwater pallasite (Fa_{18}) [4] and the Lowitz mesosiderite (Fa_{15-37}) [5] are compositionally comparable with that of Divnoe (Fa_{23-29}) [1], and it was expected that exsolved olivine grains would be found there. Olivines from other samples were studied for comparison.

No lamellar structure was observed in BSE images of the olivine grains studied. The variations of Fa contents in olivine grains from all samples but Springwater and Lowitz meteorites display no regular pattern, and are basically within the 2σ uncertainty range (±0.2 mol% Fa). As expected, olivines from the Lowitz mesosiderite and, especially, from the Springwater pallasite display somewhat larger variations, within the ranges of 20.1–21.0 mol% and 15.8–17.7 mol% Fa respectively. The olivine in Springwater shows a surprisingly regular pattern of minima spaced at ~16 μm. For reasons that are unclear, all "minima" analyses have low totals (90.47–94.31 wt%), whereas most other analyses have totals >97%. However, stoichiometry of all analyses is perfect; cation totals per four oxygens are 3.00 ± 0.01, with very minor excess of Si over Mg + Fe in the "minima" analyses.

The results obtained so far suggest that lamellar structure of olivine grains in the Divnoe meteorite is unique. While chemical variability is found in the Springwater and Lowitz olivines, there is no lamellar structure, and the magnitude of the variations is 1.5–2× smaller than it is in Divnoe olivines. Since olivine compositions in Divnoe, Lowitz, and Springwater are similar, the structural differences among them must be due to different thermal histories. The lack of lamellar structure in the Lowitz olivine implies that even the slowest cooling down to 250°C recorded in mesosiderites [6] does not result in olivine exsolution.

It is possible that Divnoe experienced secondary reheating followed by prolonged low-temperature annealing. This would also account for the lack of shock features in the Divnoe opaque minerals [7] and the difference in distributions of cosmic ray track lengths and densities between olivine and pyroxene [8].

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EDWARD P. HENDERSON AND THE DEVELOPMENT OF METEORITICS AT THE SMITHSONIAN INSTITUTION, 1929–1965. H. Plotkin, Department of Philosophy, University of Western Ontario, London, Ontario N6A 3K7, Canada.

Ed Henderson's long career as Curator of Meteorites at the U.S. National Museum (1929–1965) had a tremendous impact on the development of meteoritics. As a result of his tenure, the Museum's collection of meteorites grew to become arguably the largest and finest in the world, and the Smithsonian became one of the world's leading centers for their study.

During Henderson's administration, his ability to acquire meteorites was due partially to the availability of the Roebling Fund, but more importantly, it was due to his extraordinary resourcefulness, his single-mindedness of purpose, his intuitive grasp of new directions in meteoritics, and his ability to make many influential friends who became staunch supporters of the Museum. His early efforts, however, were largely shaped by his relationship with two remarkable men: Harvey Nininger, the world's first full-time self-employed meteoriticist, and Stuart Perry, a Michigan newspaper publisher and vice president of the Associated Press who developed a strong interest in collecting and studying meteorites.

Henderson's love for meteorites and for the Smithsonian collection took him to Europe, the Philippines, the former Soviet Union, and Australia, where he aggressively hunted for meteorites and tektites, or arranged for purchases or exchanges. He also routinely contacted the owners of newly fallen meteorites to see if he could obtain material from them. Frequently he traveled to some remote spot to negotiate with the owner for a purchase. Sometimes this involved days of haggling, but Henderson was very good at this; he was a born trader.

Post-World War II advances in atomic physics and related fields completely transformed meteoritics. A new breed of scientist arose, who viewed meteorites as keys that could be used to unlock the mysteries of the origin and evolution of the solar system. Henderson generously provided these scientists with specimens from the Smithsonian's collection for their research. Although his training did not equip him to understand much of the basic science involved in this new research, he intuitively understood the importance of these advances, and wanted the Museum to participate in this exciting new development. With strong backing from some far-sighted Smithsonian administrators and the vigorous support of some of the leading scientists of the day, he succeeded in obtaining a $300,000 NASA grant for sorely needed new equipment (especially an electron microprobe), for several new positions, and for the purchase and study of meteorites and tektites. This set the stage for the establishment of a Division of Meteorites within the Department of Mineral Sciences in 1963.

Henderson's passion for meteorites, his great achievement in building up the national collection, the many friends his wise and generous management of the collection won for the Museum, and his intuitive understanding of the new direction meteoritics was moving toward helped lay the necessary foundation for the growth of the embryonic field of materials-based planetary science, and helped the Smithsonian assume a leading position in its development.

GEOPHYSICAL SIGNATURE OF THE CHESAPEAKE BAY IMPACT CRATER (LATE EOCENE). C. W. Poag, U.S. Geological Survey, Woods Hole MA 02543-1598, USA.

The Chesapeake Bay impact crater is defined on the basis of (1) seismic-reflection profiles that cross lower Chesapeake Bay and the continental shelf